

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
31 January 2002 (31.01.2002)

PCT

(10) International Publication Number
WO 02/08054 A1

(51) International Patent Classification: B63H 1/08

(21) International Application Number: PCT/US01/16526

(22) International Filing Date: 17 July 2001 (17.07.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09/620,532 20 July 2000 (20.07.2000) US
09/741,102 21 December 2000 (21.12.2000) US

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CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM,
HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK,
LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX,
MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL,
TJ, TM, TR, TT, TZ, UA, UG, US, VN, YU, ZA, ZW.

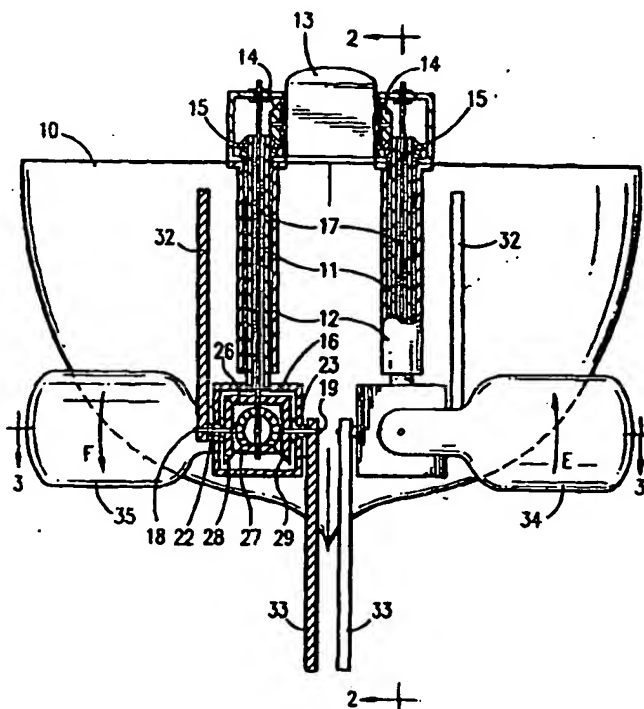
(84) Designated States (regional): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian
patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European
patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,
IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF,
CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD,
TG).

Published:
— with international search report

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(81) Designated States (national): AE, AG, AL, AM, AT, AU,
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,

(54) Title: PROPULSION SYSTEM AND METHOD



(57) Abstract: A method and system for developing a propulsive force for driving different types of water, air or land vehicles. Four blades (32, 33, 34 and 35) having preferably airfoil sections are rotated around the axis of the driving shaft (11) and around two perpendicular intercrossed axes (18, 19, 20 and 21) so that each blade lies generally in a plane perpendicular to the intercrossed axis around which it is rotated. During such double rotation the radial extensions of the blades relative to the driving shaft are changing as a function of the angle of rotation. As a result, both sides of the blades are being used consecutively as paddling surfaces and the speed of paddling motion of the blades is changing during each stroke. The rotated blades can work simultaneously both in a paddling manner and as a screw propeller. In preferred embodiments of the propulsion apparatus, the blades are constrained by planetary gear engagements in the gear-boxes (16) to rotate synchronously around the axis of the driving shaft and around the intercrossed axes. The propulsion system can include two or more parallel driving shafts (11) rotated in opposite directions for developing a unidirectional propulsive force.

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PROPULSION SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

1. Field of the invention

This invention relates generally to improvements in propeller systems, and more particularly it pertains to a new method and system for developing a propulsive force in a gaseous or liquid fluid that can be used for propulsion or sustaining aircraft, marine vessels, and different types of land vehicles, such for example, as snowmobiles, etc. Numerous other applications can be derived from the use of this invention, for example in designing apparatus for moving gaseous or liquid fluids such as fans, pumps, etc.

2. Description of the Prior Art

Historically, various propeller and paddling systems have been developed for propulsion of different types of vehicles by movement of water or air in opposite direction to the movement of the vehicle. Although at the present time, screw type propellers are the most common form of marine and aircraft propulsion, they have a number of disadvantages. Because the propeller blades are oriented at certain angles to the direction of the rotation, a lot of energy is being lost to friction with air or water, wake

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forming, vortices, cavitation, etc. The screw propellers are also relatively noisy, which may be undesirable in many situations, such as for submarines, for fishing or pleasure boats, etc.

Many improvements of the screw propellers have been suggested throughout the years. Numerous patents and researches have been devoted to development of propeller systems wherein the propeller blades are pivoted simultaneously with rotation of the driving shaft and to the problem of optimizing such cyclic variations of the orientation of individual blades. Some of such systems utilize rotation of propeller blades or paddles not only around the axis of the driving shaft but also around a complementary axes of rotation for more effective exertion of propulsive force. The basic concept presented in these systems is that the usable propulsive force is developed as a result of rotating the blades around two axes of rotation with variable orientation of the rotated blades relative to the driving shaft.

Propulsion apparatus are known (U.S. Patent Nos: 1,284,282 to Fitzpatrick, 1,450,454 to Roney, 1,667,140 to Clark, 1,923,249 to Abram) wherein blades of feathering type extend radially from the driving shaft and are rotated around radial axes simultaneously with rotation of the driving shaft. In the paddling position, the blades are held in a plane parallel to the axis of the driving shaft and in feathering position, the blades are held in a plane perpendicular to the axis of the driving shaft. A serious drawback of such systems is that in the process of changing from one position to the other, the blades have to be rotated 90 degrees

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around their longitudinal axes with a considerable resistance of the fluid and low paddling and propulsion efficiency during such rotation. That is why such systems have low propulsion efficiency in comparison with a screw type propellers.

There are also known propulsion apparatus wherein the propeller blades are oriented and rotated in the planes parallel to the driving shaft (U.S. patent No. 3,270,820 to Frazier, British patent No. 217,223 to Pensovvecchio). Although having advantages in respect to the propellers with feathering blades, such apparatus with only two blades mounted in a plane perpendicular to the propeller shaft also have low efficiency and irregular power consumption. Different combinations of such propulsion apparatus are cumbersome and the mechanisms employed to effect their operations are far too complicated to render them practical. For these reasons, a limited success has been obtained by such type of apparatus.

The invention seeks to overcome the deficiencies of known propulsion systems and to benefit from the advantages that may be expected from the new method and system.

The object of the invention is to provide a reliable propulsion system for marine vessels, aircraft and land vehicles with improved propulsion and energy efficiency.

BRIEF SUMMARY OF THE INVENTION

The invention is based on my discovery that an effective propulsive force in a liquid or gaseous fluid can be developed by rotating a driving shaft with four blades which are simultaneously rotated around two intercrossed axes which are perpendicular to each other in a plane perpendicular to the axis of the driving shaft. Each blade is oriented and held during the rotation in a plane perpendicular to the intercrossed axis around which it is rotated. The blades and the driving shaft are interconnected so that when two parallel blades, which are rotated around one of the intercrossed axis, are oriented in the same direction perpendicular to the driving shaft the other two parallel blades, which are rotated around the other of the intercrossed axis, are oriented in opposite directions along the axis of the driving shaft. Each two

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adjacent blades mounted in perpendicular planes are rotated in different directions (clockwise and counterclockwise). It was discovered that it is possible to rotate four such blades without interfering with each other simultaneously around the driving shaft and the perpendicular intercrossed axes with the same speed. During such double rotations, the radial extensions of the blades relative to the driving shaft are changing as a function of the angle of rotation. As a result, both sides of the blades are being used consecutively as paddling surfaces and the speed of paddling motion of the blades is changing during each stroke, resembling a fishtail or frog-leg action of the aquatic nature. Preferably, the blades have airfoil sections.

In preferred embodiments of the invention, the blades are constrained by the planetary gear engagements to rotate with the same speed around the axis of the driving shaft and around the intercrossed axes of the radial shafts mounted in rotated gear-boxes. Each gear-box comprises four radial shafts on which planet angle mitre gears and propeller blades are mounted. The sun gears of the planetary engagements are mounted in the gear-box coaxially to the driving shafts.

In addition, simultaneously with the paddling process, the rotated blades can work as a double screw propeller if they are mounted with angles of incidence in the planes of rotation around the radial axes. However, because the orientations of the blades are constantly changing during the rotation of the driving shaft, the angles of incidence of them must be variable. For this purpose, the blades may be mounted on the radial shafts with ability to swing around the axes perpendicular to these shafts. They can be swung by circular cams mounted coaxially with the radial shafts.

For developing a unidirectional propulsive force, the propulsion system may include two or more parallel driving shafts rotated in opposite directions. It is possible to mount the driving shafts in vertical or horizontal positions in a close proximity to each other or/and to a driven vehicle by the sides where the rotated blades are parallel to the driving shaft.

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BRIEF DESCRIPTION OF THE DRAWINGS

The objects and features of the present invention will become apparent from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

FIG. 1 is a schematic view from the stern of a boat with a preferred embodiment of the propulsion system and a fragmentary cross-section on the lines 1-1 of FIG. 2.

FIG. 2 is a cross-sectional view on the lines 2-2 of FIG. 1.

FIG. 3 is a schematic fragmentary cross-sectional top plan view on a boat with a preferred embodiment of the propulsion system on the lines 3-3 of FIG. 1.

FIG. 3a is a schematic top plan view on a boat with another way of mounting the propulsion system.

FIG. 4 schematically illustrates another embodiment of the propulsion apparatus with the blades mounted on the radial shafts with variable angles of incidence.

FIG. 5 is a cross-sectional view on the lines 5-5 of FIG. 4.

FIG. 6 is a cross-sectional view on the lines 6-6 of FIG. 4.

FIG. 7 is a schematic fragmentary cross-sectional view from the stern of a boat with another embodiment of propulsion system with the driving shafts mounted on both sides of the boat.

FIG. 8 is a cross-sectional view on lines 8-8 of FIG. 9 of a propulsion system for a marine vessel with an alternative design of the gear-boxes.

FIG. 9 is a cross-sectional view on the lines 9-9 of FIG. 8

FIG. 10 is a schematic view from the stern of a boat with another embodiment of the propulsion system having a fragmentary cross-section on the lines 10-10 of FIG. 11.

FIG. 11 is a cross-sectional view on the lines 11-11 in FIG. 10.

FIG. 12 is a schematic cross-sectional side elevation view of a vertical takeoff and landing aircraft with a propulsion system of the preferred embodiment on the lines 12-12 of FIG. 13.

FIG. 13 is a schematic fragmentary cross-sectional top plan view on the lines 13-13 of FIG. 12.

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DETAILED DESCRIPTION OF THE INVENTION

The invented propulsion system can be used in outboard motor applications for marine vessels (FIGS. 1, 2, 3) or in stern drive applications where the engine is enclosed within the hull of the vessel (FIG. 3a, 7, 10, 11). Identical details have the same indications in different embodiments.

The propulsion system illustrated in FIGS. 1, 2, 3, 3a includes two vertical hollow driving shafts 11 which are rotatably mounted in housings 12 and can be rotated in opposite directions by an internal combustion engine 13 through gear engagements 14, 15 (or any other type of drive). Planetary gear-boxes 16 are mounted on the hollow driving shafts 11. An axial support means 17 is fixed coaxially to the hollow driving shaft 11. Each gear-box 16 comprises four radial shafts 18, 19, 20 and 21 which are perpendicular to each other in a plane perpendicular to the axis of the driving shaft 11. Each of the radial shafts can be rotated in two bearings, one of which (22, 23, 24 or 25) is mounted in the wall of the gear-box and another in the central part of the gear-box (not shown). Two sun angle mitre gears 26 and 27 are mounted on the axial support means 17. Two planet angle mitre gears 28 and 29 are mounted on the radial shafts 18 and 19, respectively, so that they are engaged with the sun angle mitre gear 26. Another two planet angle mitre gears 30 and 31 are mounted on the radial shafts 20 and 21, respectively, and are engaged with the sun angle mitre gear 27. The planetary gear-boxes 16 can be filled with a lubricating oil.

Blades 32, 33, 34 and 35 are mounted on the ends of radial shafts 18, 19, 20 and 21, respectively, so that each of these blades is generally lying in a plane perpendicular to the axis of the radial shaft on which it is mounted. The blades are oriented in such a way that when two of them (34 and 35) extend in the same direction perpendicular to the driving shaft 11, the other two blades (32 and 33) extend in opposite directions parallel to the driving shaft 11. Preferably, the blades 32, 33, 34, 35 have airfoil sections.

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In operation, the planetary gear boxes 16 are rotated together with the blades 32, 33, 34, 35 in the directions indicated by arrows A and B (FIG. 3, 3a). Simultaneously, the blades 32, 33, 34, 35 are constrained by the planetary engagements of angle mitre gears 26, 28, 29 and 27, 30, 31 to rotate around the intercrossed axes of the radial shafts 18, 19, 20, 21 with the speed of rotation of the hollow driving shafts 11. The blades adjacent to each other in the perpendicular planes are rotated in opposite directions (clockwise and counterclockwise) not interfering with each other. As a result of such double rotation, the blades operate in a paddling fashion with their radial extensions relative to the axis of the hollow driving shaft 11 being changed as a function of the angle of rotation. The blades 34 and 35 which are shown in a horizontal paddling position perpendicular to the longitudinal axis of the boat 10 have the maximum extensions and, as a result, the biggest swept surface, while the other two propeller blades 32, 33 are in vertical positions parallel to the driving shafts 11 in the planes parallel to the longitudinal axis of the boat. After the next 90 degree rotation of the driving shafts 11, the blades 32, 33 come to the horizontal positions perpendicular to the longitudinal axis of the boat and the other two blades 34, 35 come to the vertical positions (not shown). The positions of the blades after 45 degree rotation of the driving shaft is shown in dashed lines. Each pair of the blades rotated around the same radial axis in opposite directions, are parallel to each other in horizontal positions. The circumferential velocity of the blades relative to the driving shafts 11 gradually increases when the orientations of the blades are changing from vertical to horizontal positions. As a result, an additional acceleration and propulsion force is produced during each of the paddling stroke of the blades.

Referring now to FIG. 3a, the similar propulsion system is shown with the vertical driving shafts 11 mounted on the stern of a boat 10, however in such a distance from each other that the blades 32, 33, 34, 35 can be directed horizontally to the longitudinal axis of the boat without interfering with each other.

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The driving shafts are shown in the positions shifted 45 degrees relative to each other.

The blades 32, 33, 34, 35 which are rotated around horizontal axes by radial shafts 18, 19, 20, 21, respectively, in opposite directions indicated by the arrows C, D, E, F, can be used as the blades of a double screw propeller. For this purpose, the blades may be mounted with angles of incidence in the planes of rotation around the horizontal axes. Because the orientations of the blades relative to the longitudinal axis of the boat 10 are changing in during the rotation of the driving shafts with both surfaces of the blades used consecutively for paddling, the angles of incidence of the blades must be variable. For this purpose, each of the blades is mounted on the radial shaft with ability to swing in the bearings 36 around the axis 37 which is fixed to the radial shaft in perpendicular direction, as illustrated in FIGS. 4-6. Four circular cams 38 are mounted on the gear-boxes 16 coaxially to the radial shafts 18, 19, 20, 21 and the followers 39, 40 are fixed to each of the blades. The cams 38 are profiled so that during the rotation of the radial shafts, the angles of incidence of the blades are changed in accordance with the positions of the blades. In vertical positions, the angles of incidence of the blades (32, 33) are zero. When the blades (34, 35) extend perpendicular to the longitudinal axis of the boat, the angles of incidence are maximum.

In the propulsion system shown in FIG. 7, two vertical driving shafts 11 are mounted on both sides of the boat 10. They are rotated in opposite directions by an engine 41 through pulleys 42, 43, a driving belt 44, a shaft 45 and gear engagements 14, 15. The engine 41 can be mounted in the hull of the boat 10.

FIGS. 8 and 9 illustrate a propulsion system with a different design of the rotated planetary gear-boxes 16. Four angle mitre gears 46, 47, 48 and 49 which are engaged with each other, are mounted in the gear-box 16 on the radial shafts 18, 19, 20 and 21, respectively. Two planet angle mitre gears 50, 51 are mounted on the radial shafts 18 and 19, respectively, so that they are engaged with the sun angle mitre gear 52 which is fixed on the axial

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support means 17. Each of the radial shafts 18, 19, 20, 21 is rotatably mounted in two bearings. One bearing (22, 23, 24 or 25) is mounted in the wall of the gear-box 16 and another bearing is mounted in the central bearing support 53. In operation, the rotation of the gear-box 16 is transmitted to the rotation of the blades 32, 33, 34, 35 by the planetary engagements of the gears 52, 50, 51 and by four engaged gears 46, 47, 48, 49.

An alternative embodiment of the propulsion apparatus for a marine vessel 54 is illustrated in FIGS. 10, 11. A horizontal hollow driving shaft, which consists of two parts 55 and 56 with a gear-box 57 fixed between them, is mounted in the housings 58 and 59 perpendicular to the longitudinal axis of the vessel 54. The design of the planetary gear-box 57 is essentially similar to the designs of the gear-boxes 16 in the embodiments of the propulsion apparatus as shown in FIGS. 1-9. A support means 17 is fixed coaxially to the hollow driving shaft on both sides of the vessel 54. Two sun angle mitre gears 26 and 27 are mounted on the support means 17 and are engaged with the planet angle mitre gears 28, 29 and 30, 31, respectively.

In operation, the hollow driving shaft is rotated together with the gear-box 57 and the blades 32, 33, 34, 35 by an engine 60 through pulleys 61, 62 and a driving belt 63 (or any other type of drive) in the direction indicated by arrow G. Simultaneously, the blades are rotated with the same speed around the axes of radial shafts. As a result of such double rotation in the vertical plane, the blades work in a paddling manner with the maximum propulsion force being exerted astern when the blades are in a vertical downward position.

Referring now to FIGS. 12 and 13, a vertical takeoff and landing aircraft is schematically shown. A propulsion system includes two hollow driving shafts mounted on both sides of the fuselage 64 of the aircraft parallel to its longitudinal axis. Each of the driving shafts consists of two parts 67 and 68 which are mounted in the housings 65, 66 with planetary gear-boxes 69 between them. Two sun angle mitre gears 70, 71 are mounted on an axial support means 72

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in each of the gear-boxes 69 and the planet angle mitre gears 73, 74, 75, 76 are mounted on the radial shafts 77, 78, 79, 80, respectively. The blades 81, 82, 83 and 84 are mounted on the ends of these radial shafts so that when the blades 81 and 82 are oriented along the longitudinal axis of the aircraft, the blades 83 and 84 extend sideways in horizontal directions from the aircraft.

In operation, the hollow driving shafts are rotated together with planetary gear-boxes 69 synchronously in opposite directions, indicated by arrows H and K, by the engines 85 and 86 through the gear engagements 87, 88. The blades on each side of the fuselage 64 are working as "flapping wings". As a result, a vertical propulsive force is exerted for lifting or sustaining the aircraft. The blades have airfoil cross-sections so that when the aircraft is moving ahead by any other type of propeller or jet engine (not shown), the blades in horizontal positions can be used as regular wings.

While this invention has been described with reference to the structures disclosed herein, they are merely chosen and described to illustrate the principle, applications, and practical use of the invention to thereby better enable others skilled in the art to utilize this invention. The preferred embodiments of the present invention illustrated in FIGS. 1-13 are not confined to the details as set forth and are not intended to be exhaustive or to limit the invention to the precise form disclosed. For example, the driving shafts can be rotatably mounted on the support means (17, 72), which can be simultaneously used for fixing the sun gears of the planetary engagements. The invention is intended to cover any modifications, which may be variously practiced within the scope of the following claims or their legal equivalents, rather than by examples given.

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CLAIMS

What is claimed is:

1. A method of developing a propulsive force in a liquid or a gaseous fluid for driving a vehicle, including:

- mounting at least one driving shaft on said vehicle;
- mounting four blades on said driving shaft with each of said blades lying generally in a plane perpendicular to one of intercrossed axes and with the ability to be rotated around said intercrossed axes, wherein:

- said intercrossed axes of rotation being perpendicular to each other in a plane perpendicular to the axis of said driving shaft;

- said four blades being constrained by said driving shaft and oriented relative to said driving shaft so that when two of said blades extend in opposite directions parallel to the axis of said driving shaft, the other two blades extend parallel to each other in a direction perpendicular to said driving shaft;

- rotating said driving shaft together with said blades around the axis of said driving shaft;

- rotating said blades around said intercrossed axes with the speed of rotation of said driving shaft so that when one said blade is rotated clockwise an adjacent blade is rotated counterclockwise in the perpendicular plane so that said blades do not interfere with each other.

2. The method of developing a propulsive force of claim 1, wherein said blades are mounted with variable angles of incidence in the planes of rotations around said intercrossed axes and work simultaneously in a paddling manner and as the blades of a screw propeller.

3. The method of developing a propulsive force of claim 2, wherein said variable angles of incidence are changed depending on the position of said blades relative to said driving shaft.

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4. The method of developing a propulsive force of claim 1, where in at least two said driving shafts are mounted on said vehicle generally parallel to each other and are rotated in opposite directions.

5. A propulsion apparatus comprising:

- at least one hollow driving shaft;
- a planetary gear-box fixed on said driving shaft;
- four radial shafts mounted in said planetary gear-box along said intercrossed axes;
- at least one sun angle mitre gear fixed coaxially with said hollow driving shaft in said planetary gear-box;
- at least one planet angle mitre gear mounted on said radial shaft and engaged with said sun angle mitre gear in said planetary gear-box;
- blades mounted on said radial shafts with each of said blade lying generally in a plane perpendicular to the axis of said radial shaft on which said blade is mounted, said blades being oriented so that when two of said blades extend parallel to the axis of said driving shaft in opposite directions, the other two of said blades are parallel to each other and extend in the direction perpendicular to said hollow driving shaft;
- means for rotating said hollow driving shaft.

6. The propulsion apparatus of claim 5, wherein two sun angle mitre gears are fixed coaxially with said hollow driving shaft and engaged with said planet angle mitre gears.

7. The propulsion apparatus of claim 5, wherein four said angle mitre gears mounted on said radial shafts are engaged with each other.

8. The propulsion apparatus of claim 5, wherein:

- at least two of said driving shafts are mounted parallel to each other with the ability to rotate in opposite directions.

9. The propulsion apparatus of claim 8, wherein there is means for synchronization of rotation of said driving shafts in opposite directions.

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10. The propulsion apparatus of claim 5, wherein said blades have airfoil sections.

11. The propulsion apparatus of claim 5, wherein said blades have variable angles of incidence in the planes of rotation around the axes of said radial shafts.

12. The propulsion apparatus of claim 11, comprising a means for changing said variable angles of incidence depending on positions of said blades relative to said driving shaft.

13. The propulsion apparatus of claim 12 wherein said means for changing said variable angles of incidence include circular cams mounted on said gear boxes.

14. A vehicle with at least one propulsion apparatus of claim 5.

15. The vehicle of claim 14, wherein said vehicle is a marine vessel.

16. The vehicle of claim 14, wherein said vehicle is an aircraft.

17. The vehicle of claim 16, wherein said blades in horizontal positions are used as regular wings for said aircraft.

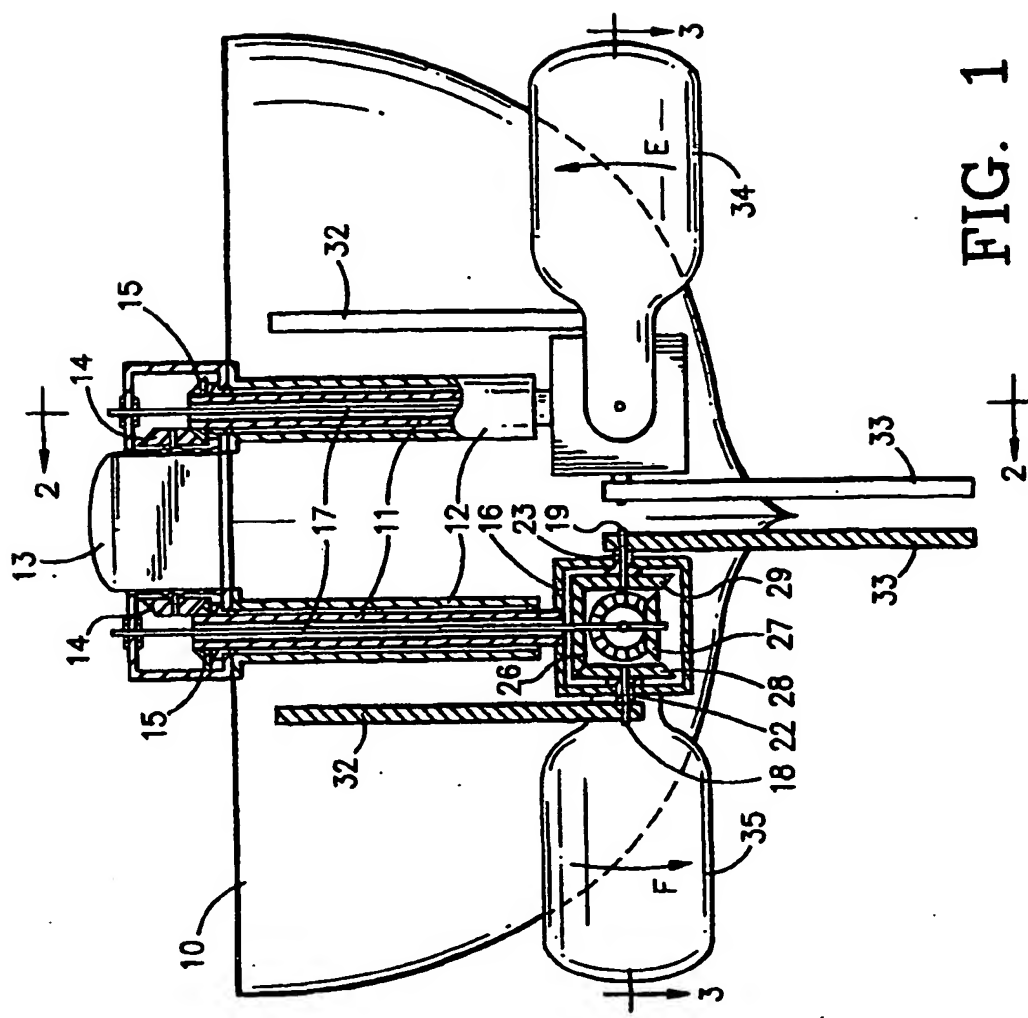
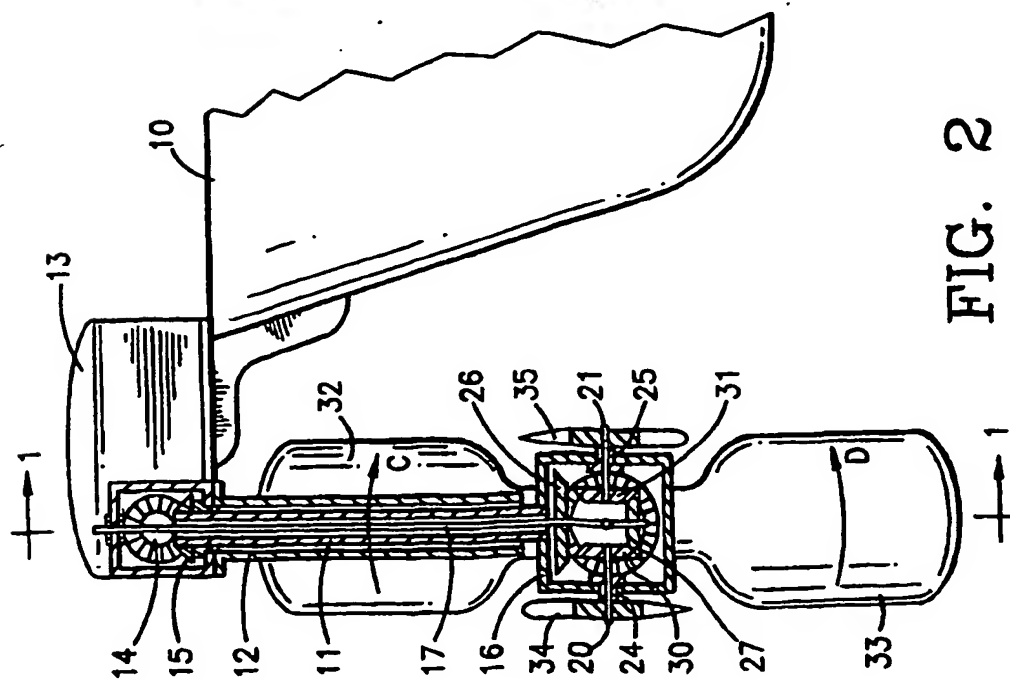


FIG. 1



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FIG.

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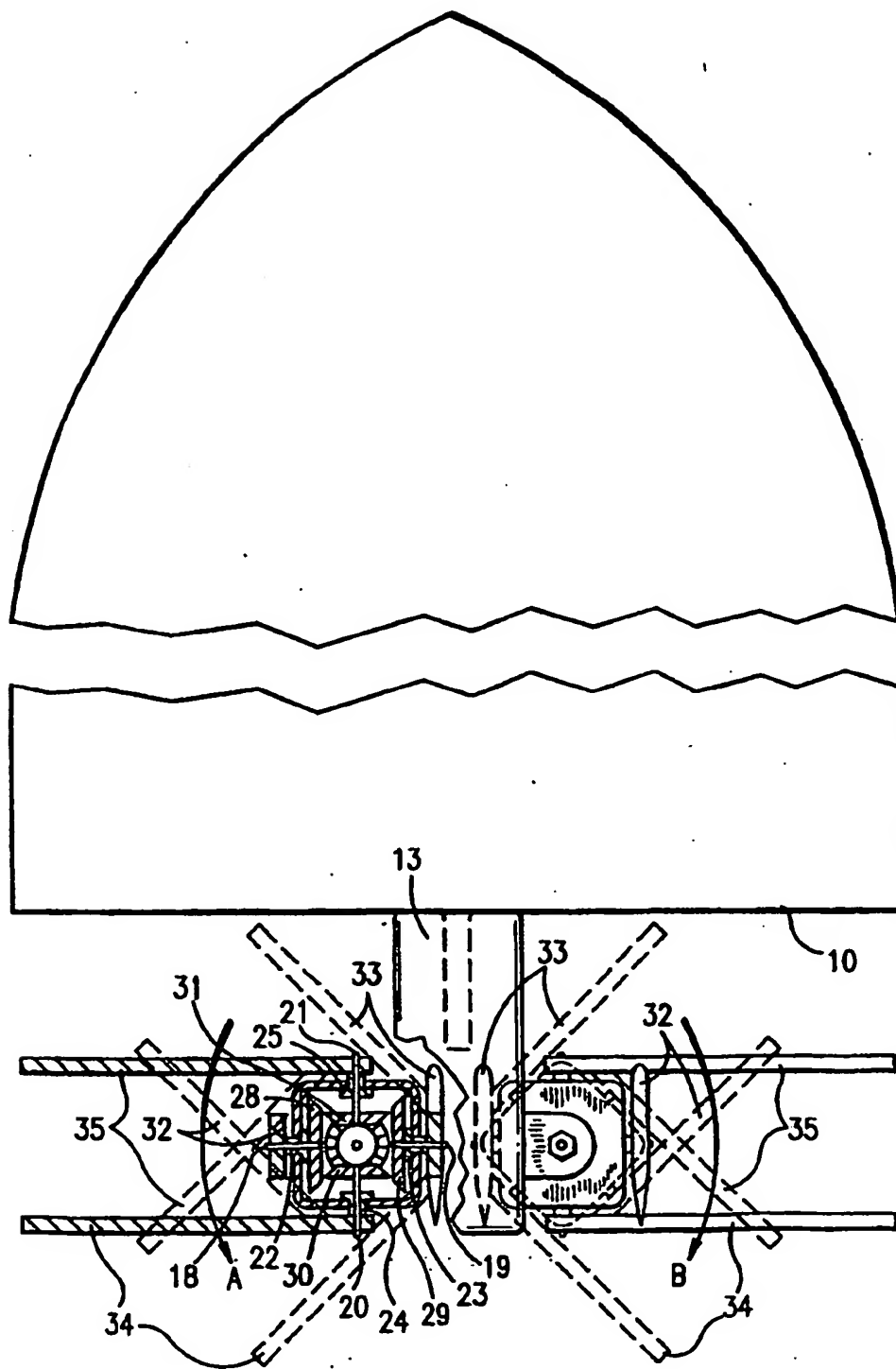


FIG. 3

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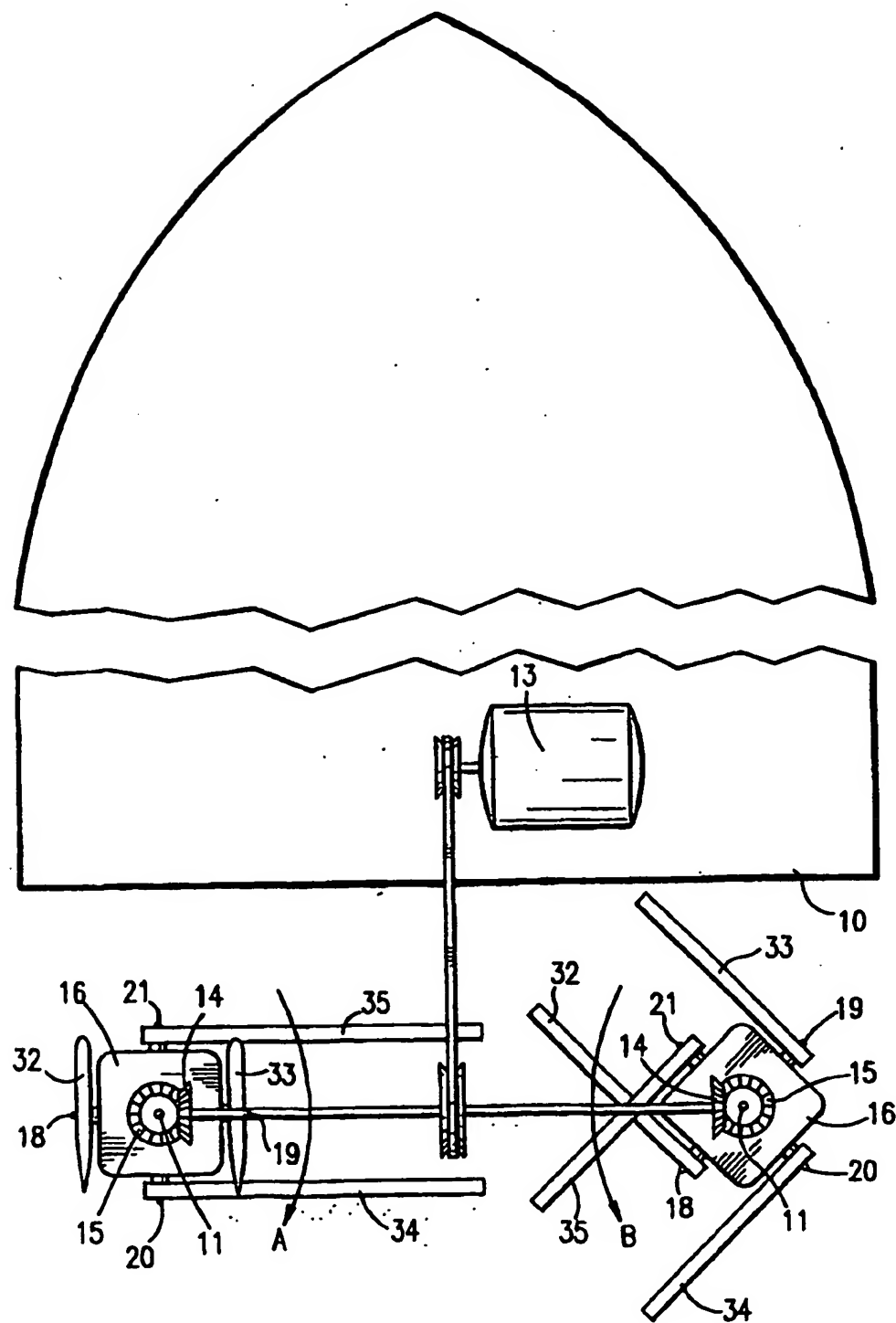


FIG. 3a

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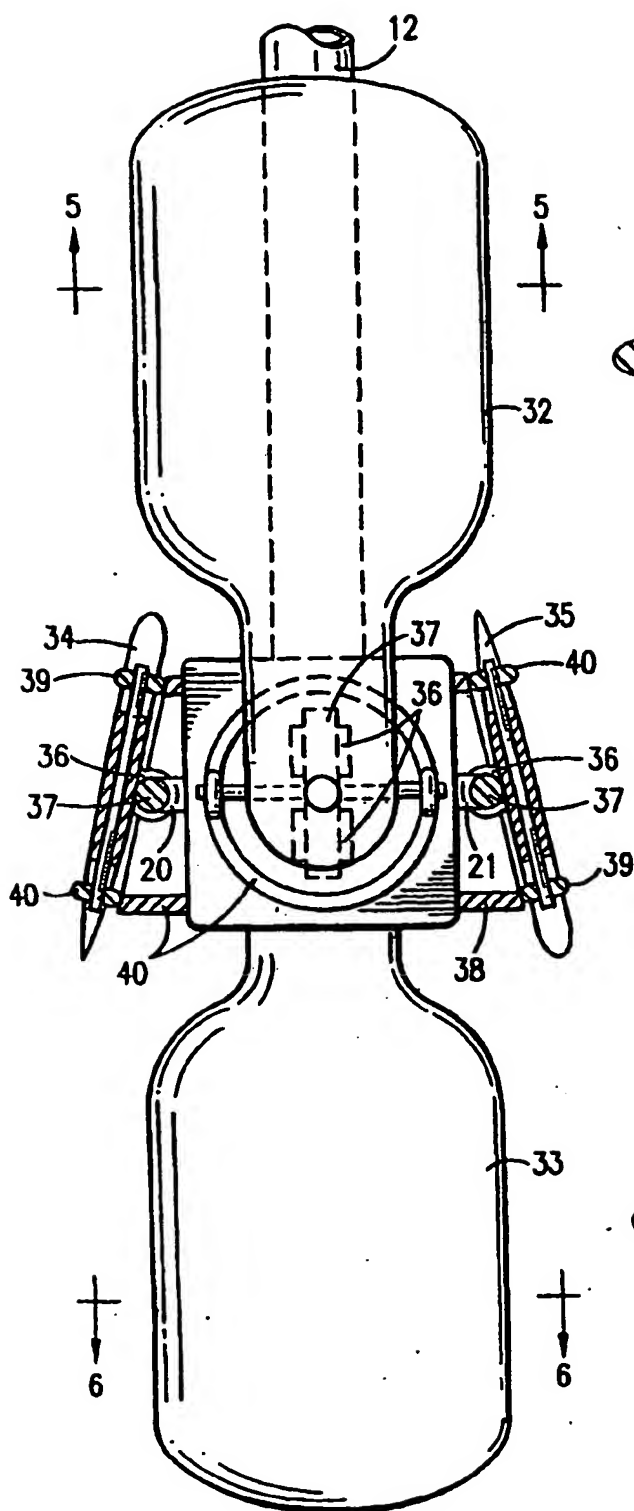


FIG. 4

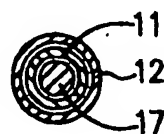


FIG. 5

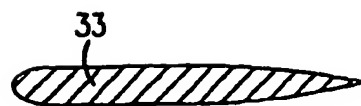


FIG. 6

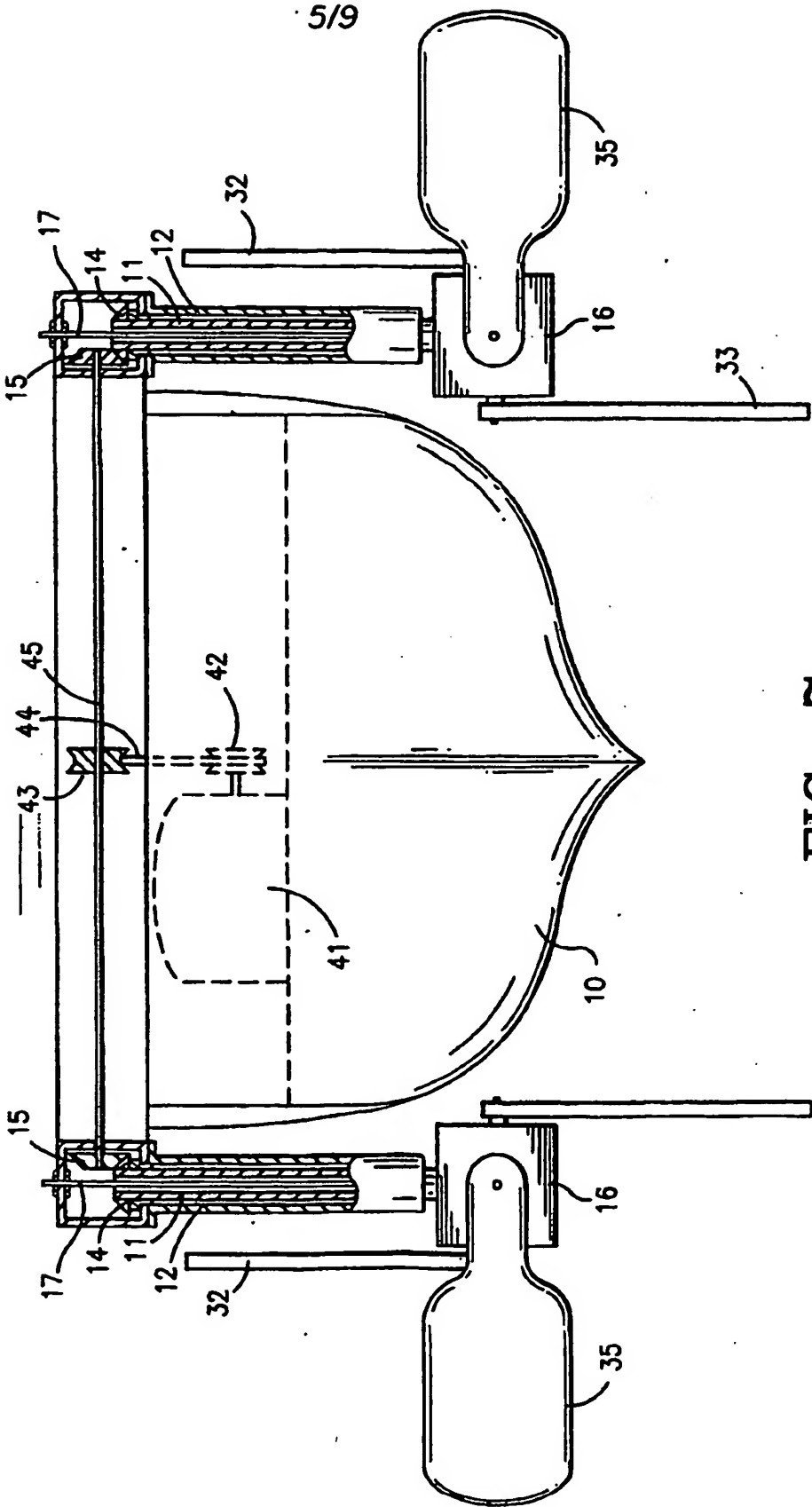


FIG. 7

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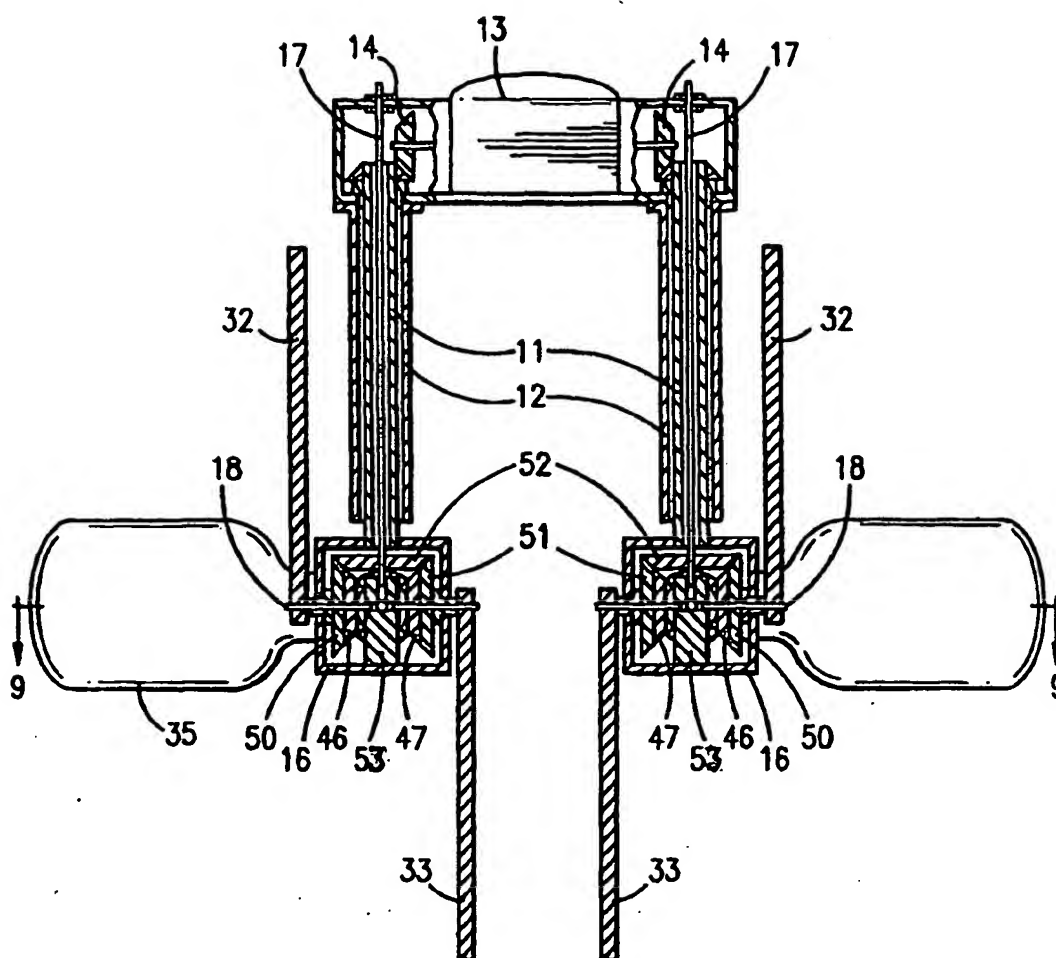


FIG. 8

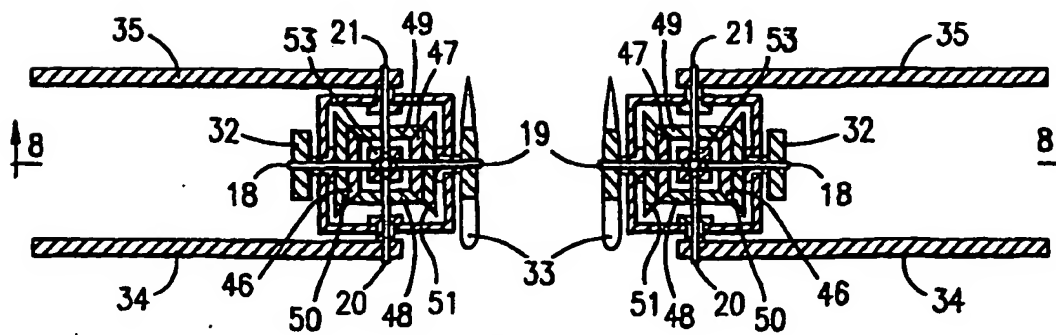


FIG. 9

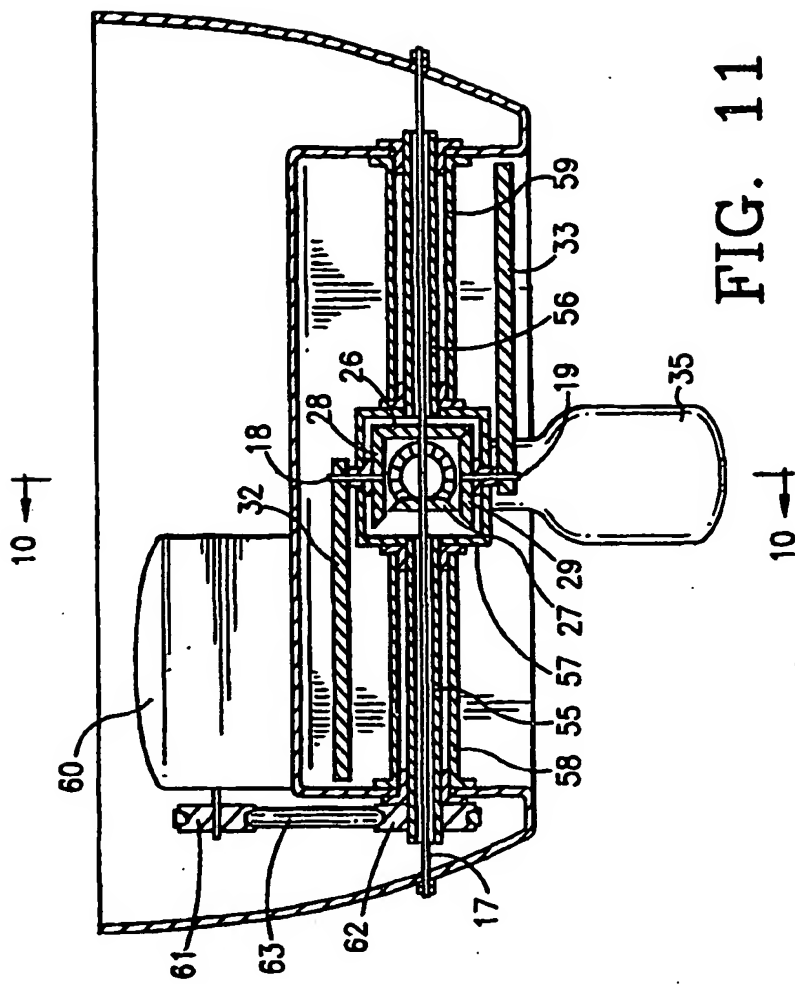


FIG. 10

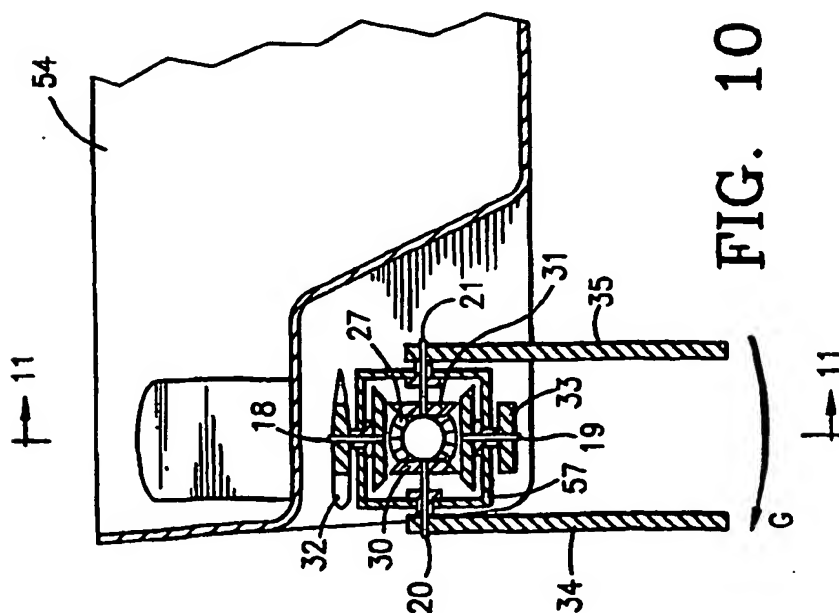


FIG. 11

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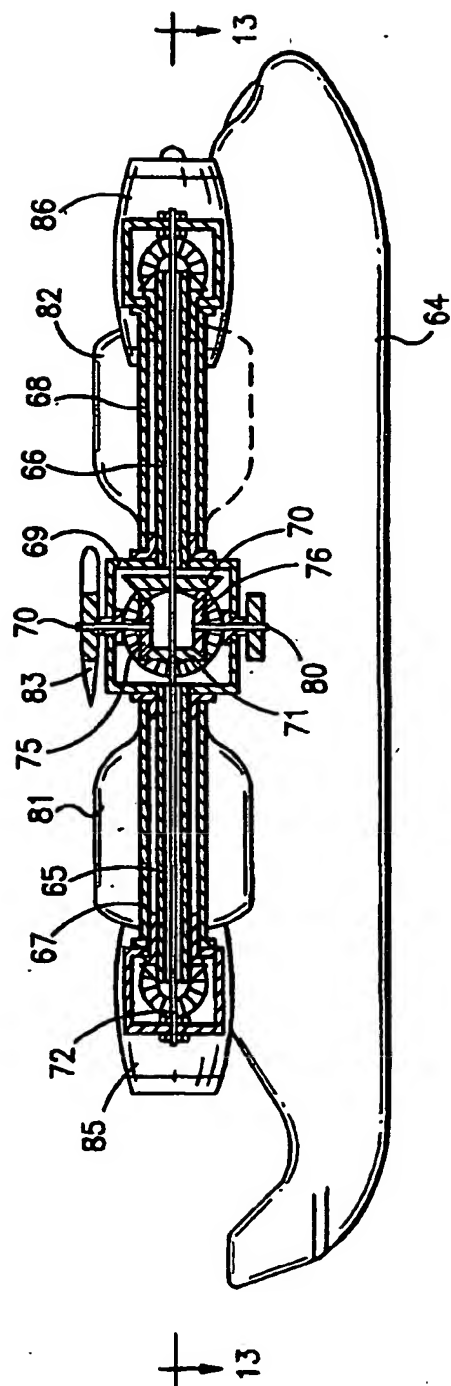


FIG. 12

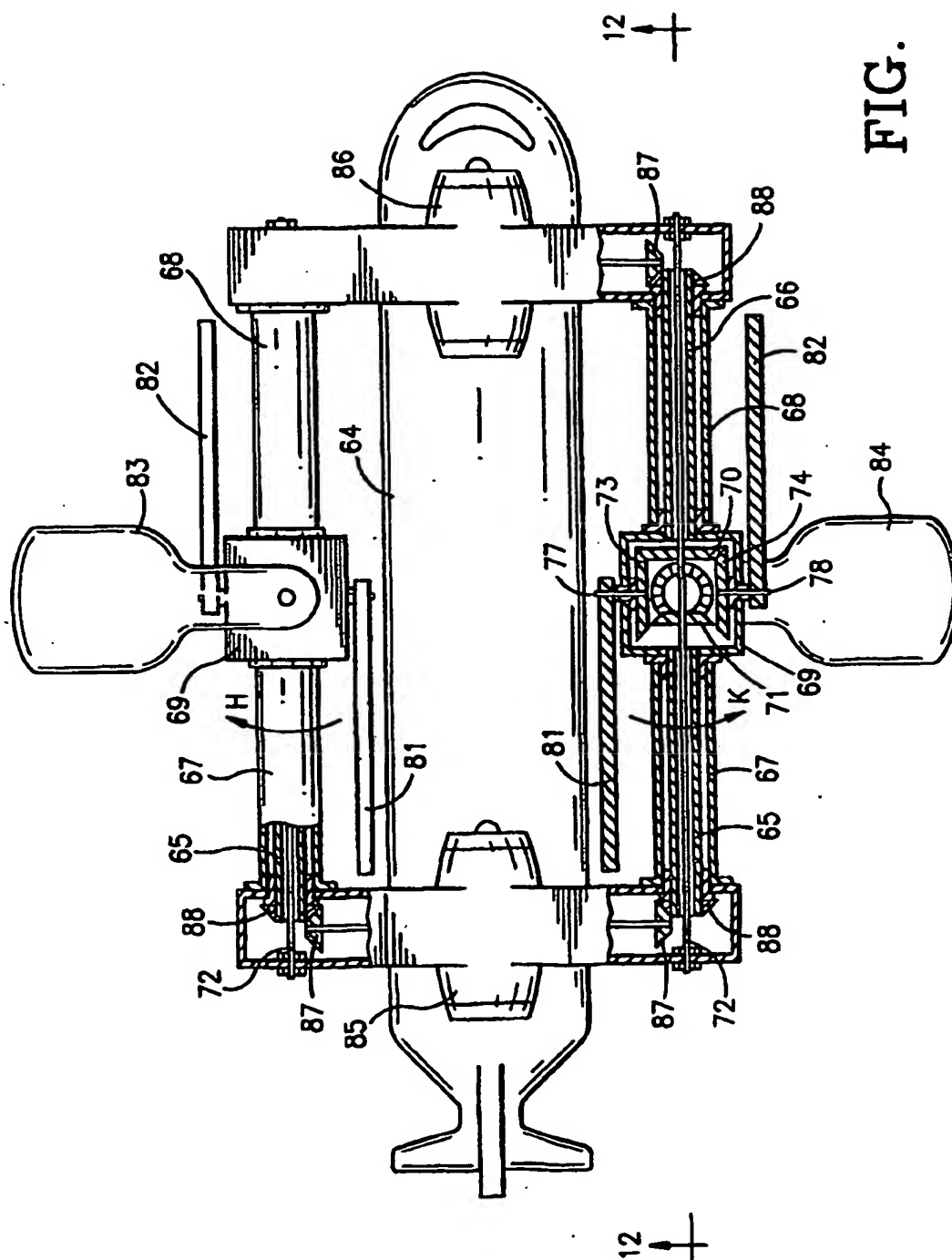


FIG. 13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/16526

A. CLASSIFICATION OF SUBJECT MATTER. IPC(7) : B63H 1/08 US CL : 244/9, 19, 70; 440/93 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 244/9, 19, 20, 70; 440/90, 92, 93; 416/110 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) Please See Continuation Sheet		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X —, P Y	US 6,227,483 B1 (THERIAULT) 08 May 2001 (08.05.2001), see figures 7-11.	1, 4 5, 7-10, 14-17
Y	US 5,326,324 A (HAMADA) 05 July 1994 (05.07.1994), see column 1, lines 25-30.	5, 7-10, 14-17
Y	US 3,738,598 A (LARKIN) 12 June 1973 (12.06.1973), see floats 33 and 35.	15
A	US 1,450,454 A (RONEY) 03 April 1923 (03.04.1923), see figure 4.	1-17
A	US 1,667,140 A (CLARK) 24 April 1928 (24.04.1928), see paddles 2.	1-17
A, & P	US 6,224,441 B1 (KABAKOV) 01 May 2001 (01.05.2001), parent patent.	1-17
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
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Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230		Authorized officer Sherman D. Basinger <i>Diana Smeyers</i> Telephone No. 703-308-1113

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US01/16526

Continuation of B. FIELDS SEARCHED Item 3:

EAST

search terms: paddle, blade, feather\$3, cycl\$3, boat, ship, airplane, aircraft, propulsion, perpendicular, parallel, propel, propelling,
drive, hollow, shaft

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